

(Eric Prebys provided the following information in an email to the Proton Team on April 28, 2003.)

I understand there was some discussion of Booster cogging in the last proton team meeting, and some confusion as to the status. Dave asked me to write a short note to everyone outlining the situation.

The Problem

Booster extraction is a fixed number of *RF cycles* from injection.

Because of cumulative phase error in the RF feedback system, this corresponds to a different amount of *time* each acceleration cycle.

For single batch injection, the Booster sets the time of transfers to the Main Injector, so that the notch can be precisely placed. The notch position will always be determined by counting RF cycles.

For multibatch operation, the main injector will have to set the precise time, at least for everything after the first batch. Since we don't know a priori how long the acceleration cycle will take, we don't know where to put the notch so it will be in the correct place at extraction.

This problem has been known for some time. 2 or 3 years ago, Bob Webber and Bill Pellico implemented a scheme that was demonstrated at low intensity.

Bob and Bill's Scheme

Most of the phase error happens early in the acceleration cycle.

They built and programmed a DSP board which monitors the RF phase lag for the first few milliseconds to get an idea "where it's going".

The notch position is corrected for this, which gets it to within about half a turn ($\pm 1/4$ turn) of where it belongs.

From there on, the acceleration time is fixed by feeding back *time* deviations to the radial position feedback system. This requires motion on the order of a millimeter or so.

Problems with the Scheme

It has only been demonstrated at low intensity. Varying the radial offset will probably cause stability problems at high intensity.

The best performance demonstrated still required a notch 2-3 times bigger than our current notch, and the notch will have to be created at slightly higher energy, so it

dramatically increases our tunnel radiation.

Since this notch must be created after a few milliseconds, it is NOT consistent with any of the proposed pre-notching schemes on the table, although it might be consistent with resonant notch creation.

It's not clear how compatible the radial position variation will be with horizontal collimation.

Status

Basically, NOTHING has happened with this system since Bob and Bill demonstrated it (before I ever got here).

Recently, Bob Zwaska, a MINOS grad student from UT Austin has come to the lab to focus entirely on this issue. He's a good guy, with some beamline experience, but he came with no RF experience whatsoever.

He's been working closely with Bill Pellico. Their first task was to repeat the original test. Not surprisingly, the system has been badly cannibalized and there have been a number of other problems in doing this.

They've recently had some big breakthroughs and I believe are on the verge of making the old system work.

My personal hope is that with someone focusing on this full time, we will learn more about the actual mechanism of the problem, and may find some other way to address this issue.

I hope this clears things up.

-Eric